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(71) Applicant (for all designated States except US): **PFIZER  
PRODUCTS INC.** [US/US]; Eastern Point Road, Groton,  
CT 06340 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **LOWE, John,  
Adams, III** [US/US]; Pfizer Global Research and De-  
velopment, Eastern Point Road, Groton, CT 06340 (US).  
**SANNER, Mark, Allen** [US/US]; Pfizer Global Research  
and Development, Eastern Point Road, Groton, CT 06340  
(US).

(74) Agent: **FULLER, Grover, E., Jr.**; Pfizer Inc., 201 Tabor  
Road, Morris Plains, CT 06340 (US).

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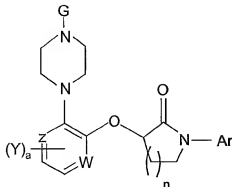
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(54) Title: NOVEL PIPERAZINYL-ARYLOXY AND PIPERAZINYL-HETEROARYLOXY-N-ARYL LACTAMS



(I)

(57) Abstract: The present invention relates to compounds of formula (I), wherein Ar, Y and G are as defined in the specification, a is 1 to 4, Z and W are carbon or nitrogen and n is 1, 2 or 3; and to pharmaceutical compositions comprising the compound of formula (I) and a pharmaceutically effective carrier; and to a method useful in treating or preventing in mammals, including humans, a disorder or condition selected from the group consisting of anxiety, depression, dysthymia, major depressive disorder, migraine, posttraumatic stress disorder, avoidant personality disorder, borderline personality disorder and phobias.

WO 2004/110994 A1

**NOVEL PIPERAZINYL-ARYLOXY AND PIPERAZINYL-HETEROARYLOXY-N-ARYL  
LACTAMS**

**Field of the Invention**

This invention relates to certain piperazinyl-aryloxy and piperazinyl-heteroaryloxy-N-ary  
5 laryl lactams and to their use in treating diseases or conditions which are caused by disorders of the serotonin system.

**Background of the Invention**

Serotonin plays a role in several psychiatric disorders, including anxiety, Alzheimer's disease, depression, nausea and vomiting, eating disorders, and migraine. (Rasmussen *et al.*, "Chapter 1. Recent Progress in Serotonin (5HT), Receptor Modulators", in *Annual Reports in Medicinal Chemistry, Section 1*, 30, pp. 1-9, 1995, Academic Press). Serotonin also plays a  
10 role in both the positive and negative symptoms of schizophrenia. (Sharma *et al.*, *Psychiatric Annals*, 26 (2), pp. 88-92 (1996))

Numerous receptor subtypes have been classified according to their antagonist  
15 susceptibilities and their affinities for 5HT. The 5HT<sub>1B</sub> receptor was first identified in rats, where it has a distinct pharmacological profile. In humans, however, it shares an almost identical pharmacology with the 5HT<sub>1D</sub> receptor. In the CNS, the receptor is found in the striatum, medulla, hippocampus, frontal cortex and amygdala. In the periphery, it is found in  
20 vascular smooth muscle. The 5HT<sub>1B</sub>/5HT<sub>1D</sub> receptor may be the therapeutic substrate of the anti-migraine drug, sumatriptan; this receptor is also implicated in feeding behavior, anxiety, depression, cardiac function and movement. (Watson, S., and Arkinstall, S.)

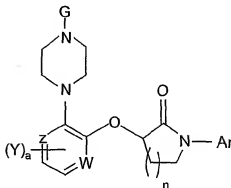
Selective agonists and antagonists for 5HT<sub>1B</sub> receptors have until now been lacking, but indirect pharmacological evidence suggests that 5HT<sub>1B</sub> activation influences food intake, sexual activity, locomotion, and aggression. (Ramboz S., *et al.*, *Behav. Brain Res.*, 73: 305-  
25 312 (1996)).

Accordingly, the present invention provides compounds that are antagonists of the serotonin 5HT<sub>1B</sub> receptor, and are effective for the treatment of disorders of the serotonin system, such as depression and related disorders.

-2-

Summary of the Invention

This invention relates to piperaziny-aryloxy and piperaziny-heteroaryloxy-N-aryl lactams of the formula I



5 wherein Ar is selected from phenyl, naphthyl and heteroaryl, wherein said heteroaryl is selected from five to seven membered aromatic rings or eight to ten membered fused aromatic ring systems containing from one to four heteroatoms selected from oxygen, nitrogen and sulfur, and

10 wherein Ar may be optionally substituted with one or more substituents, preferably from zero to two substituents, independently selected from halogen, trifluoromethyl, hydroxy, nitro, cyano,  $R_1$ ,  $OR_2$ ,  $-OC(=O)R_3$ ,  $-COOR_4$ ,  $NHR_5$ ,  $NR_6R_6$ ,  $-NHC(=O)R_6$ ,  $N(R_6)(C=O)R_6$ ,  $-C(=O)NHR_6$ , phenyl, naphthyl, heteroaryl, or a 5 to 7 membered heteroalkyl ring, and

wherein said heteroaryl substituent is selected from five to seven membered aromatic rings containing from one to four heteroatoms selected from oxygen, nitrogen and sulfur, and

15 wherein said 5 to 7 membered heteroalkyl ring substituent has from zero to four heteroatoms selected from nitrogen, sulfur and oxygen, with the proviso that said ring cannot contain two adjacent oxygen atoms or two adjacent sulfur atoms, and

20 wherein said phenyl, naphthyl, heteroaryl and heteroalkyl ring substituents may be optionally substituted with one or more substituents, preferably from zero to two substituents, independently selected from halogen, trifluoromethyl, hydroxy, nitro, cyano,  $R_1$ ,  $OR_2$ ,  $-OC(=O)R_3$ ,  $-COOR_4$ ,  $NHR_5$ ,  $NR_6R_6$ ,  $-NHC(=O)R_6$ ,  $N(R_6)(C=O)R_6$ ,  $-C(=O)NHR_6$  and wherein said heteroalkyl ring may also be substituted with oxo;

25 Y is hydrogen, halogen, hydroxy, nitro, cyano or  $R_7$ , where  $R_1$ - $R_7$  are independently  $C_1$ - $C_8$  alkyl,  $C_2$ - $C_8$  alkenyl,  $C_1$ - $C_8$  alkoxy, or  $C_1$ - $C_8$  alkenoxy, said alkyl, alkenyl, alkoxy or alkenoxy being optionally substituted with one or more halogen atoms or nitro, cyano or hydroxyl groups, said alkyl or alkenyl groups being straight-chain, branched or cyclic, or, in the case of  $NR_5R_6$ ,  $R_5$  and  $R_6$  together with the nitrogen to which they are attached may be linked together to form a five or six membered ring;

-3-

G is (C<sub>1</sub>-C<sub>6</sub>)alkyl or benzyl, wherein said alkyl is straight-chained, branched or cyclic, and said (C<sub>1</sub>-C<sub>6</sub>) alkyl is optionally substituted with OH, or OR', wherein R' is straight-chained, branched or cyclic (C<sub>1</sub>-C<sub>6</sub>)alkyl;

a is 1 to 4;

5 Z and W are independently carbon or nitrogen;

n is 1, 2 or 3;

and to pharmaceutically acceptable salts thereof.

The invention is also directed to pharmaceutical compositions comprising the compound of Formula I and a pharmaceutically effective carrier.

10 The invention is also directed to a method of treating or preventing a disorder or condition that can be treated or prevented by altering serotonin-mediated neurotransmission in a mammal, including a human comprising administering to a mammal or human in need of such treatment an effective amount of the compound of Formula I or a pharmaceutically acceptable salt thereof.

15 The invention is also directed to a method of treating, in a mammal, including a human, a disorder or condition selected from the group consisting of anxiety, depression, dysthymia, major depressive disorder, migraine, post-traumatic stress disorder, avoidant personality disorder, borderline personality disorder and phobias comprising administering to a mammal or human in need of such treatment an effective amount of the compound of Formula I or a pharmaceutically acceptable salt thereof.

20 The invention is also directed to any of the foregoing methods wherein the compound of Formula I, or a pharmaceutically acceptable salt thereof, is administered in combination with a serotonin reuptake inhibitor (SRI) (e.g., sertraline, fluoxetine, fenfluramine, or fluvoxamine). The term "administered in combination with," as used herein, means that the compound of Formula I or pharmaceutically acceptable salt thereof is administered in the form of a pharmaceutical composition that also contains an SRI, or that such compound or salt is administered in a separate pharmaceutical composition from that in which the SRI is administered, but as part of a dose regimen that calls for the administration of both active agents for treatment of a particular disorder or condition.

30 Specific compounds that exemplify the invention include but are not limited to:  
 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one  
 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-bromo-phenyl)-pyrrolidin-2-one  
 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-(2-oxo-pyrrolidin-1-yl)-phenyl)-pyrrolidin-2-one  
 35 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-bromo-phenyl]-piperidin-2-one  
 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-pyrrolidin-1-yl)-phenyl]-piperidin-2-one

- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-oxazolidin-3-yl)-phenyl]-piperidin-2-one
- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-piperidin-2-one
- 1-(4-Trifluoromethyl-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 5 2-one
- 1-(4-tert-Butyl-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 1-[4-(2-tert-Butyl-oxazol-4-yl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 1-(4-[3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-2-oxo-pyrrolidin-1-yl]-phenyl)-piperidin-2-one
- 10 piperidin-2-one
- 1-(4-[3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-2-oxo-pyrrolidin-1-yl]-phenyl)-pyrrolidinone
- 1-[4-(3-pyridyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 1-[4-(4-pyridyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 15 1-[4-(Isopropoxy)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 1-[4-(Trifluoromethoxy)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-1-[4-(tetrahydro-pyran-4-yl)-phenyl]-pyrrolidin-2-one
- 20 pyrrolidin-2-one
- 1-[4-(2-Oxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 1-[4-(1-Pyazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 25 1-[4-(4-(2-Methyl)oxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 1-[4-(3-Isoxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- one
- 1-[4-(2-(5-Methyl)oxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one
- 30 pyrrolidin-2-one
- 3-(4-Methyl-3,4,5,6-tetrahydro-2H-[1,2']bipyrazinyl-3'-yloxy)-1-(4-pyridin-3-yl-phenyl)-pyrrolidin-2-one
- 3-(4-Methyl-3,4,5,6-tetrahydro-2H-[1,2']bipyrazinyl-3'-yloxy)-1-(4-pyridin-4-yl-phenyl)-pyrrolidin-2-one
- 35 3-(4-Methyl-3,4,5,6-tetrahydro-2H-[1,2']bipyrazinyl-3'-yloxy)-1-(4-(1-pyrrolidin-2-one)-phenyl)-pyrrolidin-2-one

3-(4-Methyl-3,4,5,6-tetrahydro-2H-[1,2]bipyrazinyl-3'-yloxy)-1-(4-(1-piperidin-2-one)-phenyl)-pyrrolidin-2-one

3-(4-Methyl-3,4,5,6-tetrahydro-2H-[1,2]bipyrazinyl-3'-yloxy)-1-(4-t-butyl-phenyl)-pyrrolidin-2-one

5 3-(4-Methyl-3,4,5,6-tetrahydro-2H-[1,2]bipyrazinyl-3'-yloxy)-1-(4-isopropoxy-phenyl)-pyrrolidin-2-one

3-(4-Methyl-3,4,5,6-tetrahydro-2H-[1,2]bipyrazinyl-3'-yloxy)-1-(4-isopropyl-phenyl)-pyrrolidin-2-one

10 3-[3-(4-Methyl-piperazin-1-yl)-pyridin-2-yloxy]-1-(4-pyridin-3-yl-phenyl)-pyrrolidin-2-one

3-[3-(4-Methyl-piperazin-1-yl)-pyridin-2-yloxy]-1-(4-pyridin-4-yl-phenyl)-pyrrolidin-2-one

3-[3-(4-Methyl-piperazin-1-yl)-pyridin-2-yloxy]-1-(4-isopropoxy-phenyl)-pyrrolidin-2-one

15 3-[3-(4-Methyl-piperazin-1-yl)-pyridin-2-yloxy]-1-(4-t-butyl-phenyl)-pyrrolidin-2-one

3-[3-(4-Methyl-piperazin-1-yl)-pyridin-2-yloxy]-1-((1-pyrrolidin-2-one)-phenyl)-pyrrolidin-2-one

3-[3-(4-Methyl-piperazin-1-yl)-pyridin-2-yloxy]-1-(4-(1-piperidin-2-one)-phenyl)-pyrrolidin-2-one

20 3-[3-(4-Methyl-piperazin-1-yl)-pyridin-2-yloxy]-1-(4-isopropyl-phenyl)-pyrrolidin-2-one

The pharmaceutically acceptable acid addition salts of compounds of the Formula I may be used, as referred to above, in the various methods of this invention. The compounds of Formula I are basic in nature and are thus capable of forming a wide variety of salts with various inorganic and organic acids. The acids that may be used to prepare pharmaceutically acceptable acid addition salts of those compounds of Formula I are those that form non-toxic acid addition salts, i.e., salts containing pharmacologically acceptable anions, such as the hydrochloride, hydrobromide, hydroiodide, nitrate, sulfate, bisulfate, phosphate, acid phosphate, isonicotinate, acetate, lactate, salicylate, citrate, acid citrate, tartrate, pantothenate, bitartrate, ascorbate, succinate, maleate, fumarate, gluconate, glucuronate, saccharate, formate, benzoate, glutamate, methanesulfonate, ethanesulfonate, benzenesulfonate, and p-toluenesulfonate.

The term "one or more substituents", as used herein, includes from one to the maximum number of substituents possible based on the number of available bonding sites.

The term "disorders of the serotonin system", as used herein, refers to disorders the treatment of which can be effected or facilitated by altering (i.e., increasing or decreasing) serotonin-mediated neurotransmission.

The term "treating", as used herein, refers to retarding or reversing the progress of, or alleviating or preventing either the disorder or condition to which the term "treating" applies, or one or more symptoms of such disorder or condition. The term "treatment", as used herein, refers to the act of treating a disorder or condition, as the term "treating" is defined above.

- 5       The term "treatment effective amount," as used herein, refers to an amount sufficient to detectably treat, ameliorate, prevent or detectably retard the progression of an unwanted condition or symptom associated with disorders of the serotonin system.

10       The chemist of ordinary skill will recognize that certain combinations of substituents included within the scope of formula I may be chemically unstable and will avoid these combinations or alternatively protect sensitive groups with well known protecting groups.

15       The term "alkyl", as used herein, unless otherwise indicated, includes saturated monovalent hydrocarbon radicals with 1-12 carbon atoms having straight, branched or cyclic moieties or combinations thereof. The term "lower alkyl" refers to an alkyl group having one to six carbon atoms. Examples include methyl, ethyl, propyl, isopropyl, cyclopropyl, butyl, isobutyl, sec-butyl, t-butyl, pentyl, neopentyl, cyclopentylmethyl, and hexyl. It is preferred that the alkyl group is lower alkyl. The preferred lower alkyl group contains 1-3 carbon atoms. The most preferred alkyl group is methyl.

20       The term "alkoxy", as used herein, unless otherwise indicated, refers to radicals having the formula -O-alkyl, wherein "alkyl" is defined as above. As used herein, the term "lower alkoxy" refers to an alkoxy group having 1-6 carbon atoms. It may be straight chain or branched. Examples include methoxy, ethoxy, propoxy, isopropoxy, butoxy, isobutoxy, pentoxy and the like. It is preferred that alkoxy is lower alkoxy. It is more preferred that alkoxy contains 1-3 carbon atoms. The most preferred alkoxy group is methoxy.

25       The halogen atoms contemplated by the present invention are F, Cl, Br, and I. Chlorine and fluorine are preferred. Alkyl groups substituted with one or more halogen atoms include chloromethyl, 2,3-dichloropropyl, and trifluoromethyl. It is preferred that the halo groups are the same. The most preferred is trifluoromethyl.

30       The term "alkenyl" as used herein refers to a hydrocarbon radical with two to eight carbon atoms and at least one double bond. The alkenyl group may be straight-chained, branched, or cyclic, and may be in either the Z or E form. Examples include ethenyl, 1-propenyl, 2-propenyl, 1-butenyl, 2-butenyl, isopropenyl, isobutenyl, 1-pentenyl, (Z)-2-pentenyl, (E)-2-pentenyl, (Z)-4-methyl-2-pentenyl, (E)-4-methyl-2-pentenyl, 1,3-pentadienyl, 2,4-pentadienyl, 1,3-butadienyl, cyclopentadienyl, and the like. The preferred alkenyl group is ethenyl.

35       The term "alkynyl" refers to a hydrocarbon radical with two to eight carbon atoms and at least one carbon-carbon triple bond. The alkynyl group may be straight chained or branched. Examples include 1-propynyl, 2-propynyl, 1-butylnyl, 2-butylnyl, 1-pentylnyl, 2-

-7-

pentynyl, 3-methyl-1-pentynyl, 3-pentynyl, 1-hexynyl, 2-hexynyl, 3-hexynyl, and the like. The preferred alkynyl group is ethynyl.

The term "aryl", as used herein, unless otherwise indicated, includes an organic radical derived from a C<sub>6</sub>-C<sub>14</sub> aromatic hydrocarbon by removal of one or more hydrogen(s).

5 Examples include phenyl and naphthyl.

The term "heteroaryl", as used herein, unless otherwise indicated, includes an organic radical derived from an aromatic heterocyclic compound by removal of one or more hydrogens. Examples of heteroaryl groups include benzimidazolyl, benzofuranyl, benzofurazanyl, 2H-1-benzopyranyl, benzothiadiazine, benzothiazinyl, benzothiazolyl, 10 benzothiophenyl, benzoxazolyl, furazanyl, furopyridinyl, furyl, imidazolyl, indazolyl, indolinyl, indoliziny, indolyl, 3H-indolyl, isoindolyl, isoquinoliny, isothiazolyl, isoxazolyl, naphthyridinyl, oxadiazolyl, oxazolyl, phthalazinyl, pteridinyl, purinyl, pyrazinyl, pyridazinyl, pyridinyl or pyridyl, pyrimidinyl, pyrazolyl, pyrrolyl, quinazoliny, quinolinyl, quinoxaliny, tetrazolyl, thiazolyl, thiadiazolyl, thienyl, triazinyl and triazolyl.

15 The term "heterocyclic compound" denotes a ring system made up of 5 - 14 ring atoms and made up of carbon and at least one other element selected from the group consisting of oxygen, nitrogen, and sulfur.

The term "5 to 7 membered heteroalkyl ring" includes pyrrolidinyl, piperidyl, piperazinyl, morpholinyl, thiomorpholinyl, diazepinyl, oxazepinyl, thiazepinyl, oxadiazepinyl, 20 thiadiazepinyl or triazepinyl, as well as compounds having one or more carbonyl groups within the ring such as pyrrolidin-2-one and piperidin-2-one.

The compounds of Formula I contain one or more chiral centers, and therefore exist in different enantiomeric and diastereomeric forms. Formula I, as defined above, includes, and this invention relates to the use of, all optical isomers and other stereoisomers of 25 compounds of the Formula I and mixtures thereof.

5HT receptor ligands are of clinical use in the treatment of a wide variety of disorders related to serotonin-mediated physiological pathways.

This invention is also directed to a method of treating a disorder or condition that can be treated by altering (i.e., increasing or decreasing) serotonin-mediated neurotransmission in 30 a mammal, including a human, comprising administering to said mammal an amount of a compound of the Formula I, as defined above, or a pharmaceutically acceptable salt thereof, that is effective in treating such disorder or condition.

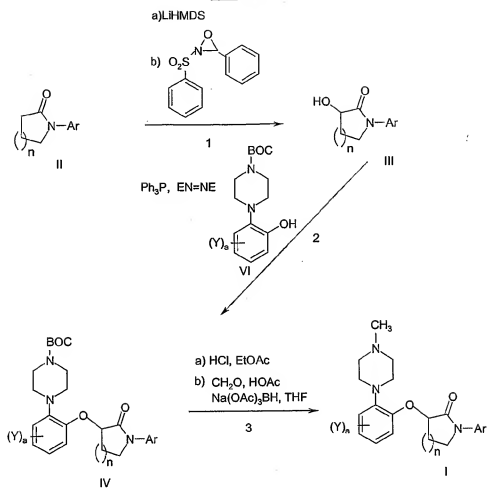
This invention is also directed to a method of treating migraine, headache or cluster headache in a mammal, including a human, comprising administering to said mammal an 35 amount of a compound of the Formula I, as defined above, or a pharmaceutically acceptable salt thereof, that is effective in treating such disorder.



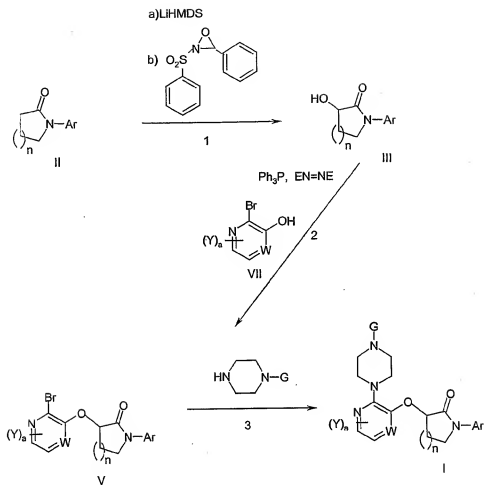
- This invention is also directed to a method of treating a disorder selected from, depression (i.e., dysthymia, major depressive disorder, pediatric depression, recurrent depression, single episode depression, post partum depression, depression in Parkinson's patients, cancer patients, and post myocardial infarction patients, and subsyndromal symptomatic depression) generalized anxiety disorder, panic disorder, obsessive-compulsive disorder, post-traumatic stress disorder, avoidant personality disorder, borderline personality disorder and phobias in a mammal, including a human, comprising administering to said mammal an amount of a compound of the formula I, as defined above, or a pharmaceutically acceptable salt thereof, that is effective in treating such disorder.
- Formula I above includes compounds identical to those depicted but for the fact that one or more atoms (for example, hydrogen, carbon or fluorine atoms) are replaced by radioactive isotopes thereof. Such radiolabeled compounds are useful as research and diagnostic tools in, for example, metabolism studies, pharmacokinetic studies and binding assays.
- This invention is also directed to a method, such as positron emission tomography (PET), of obtaining images of a mammal, including a human, to which a radiolabeled compound of the Formula I, or pharmaceutically acceptable salt thereof, has been administered. Such imaging methods can potentially be used for any organ or system in which the 5-HT<sub>1B</sub> receptor is found, such as those indicated above. The utility of radioactive agents with affinity for 5HT receptors for visualizing organs of the body either directly or indirectly has been documented in the literature. For example, C.-Y. Shiue *et al.*, *Synapse*, 25, 147 (1997), and S. Houle *et al.*, *Can. Nucl. Med. Commun.*, 18, 1130 (1997), describe the use of 5HT<sub>1A</sub> receptor ligands to image 5HT<sub>1A</sub> receptors in the human brain using positron emission tomography (PET). The foregoing references are incorporated herein by reference in their entireties.

#### Detailed Description of the Invention

- The compounds of formula I can be prepared according to the methods of Scheme 1 and Scheme 2. Except where otherwise stated, Ar, Y, Z, G, a and n in the reaction schemes and discussion that follow are defined as above. Unless otherwise stated reaction conditions include an inert atmosphere commonly used in the art such as nitrogen or argon.

**SCHEME 1**

-10-

**SCHEME 2**

5

Scheme 1 refers to the preparation of a compound of the formula I wherein Z is CH.  
In step 1 of Scheme 1, a compound of the formula III, which is a precursor of the compound

of formula I, is prepared from a compound of the formula II, by a) treatment with a strong base such as lithium, sodium or potassium hexamethyldisilazide, preferably lithium hexamethyldisilazide, in an ethereal solvent such as diethylether, dioxane or tetrahydrofuran (THF), preferably THF, at about -100°C to about -40°C, preferably about -78°C, for about 30 minutes to about 5 hours, preferably about 45 minutes followed by b) addition of (N-benzenesulfonyl)-phenyloxaziridine, in an ethereal solvent such as diethylether, dioxane or tetrahydrofuran, preferably THF, and allowing the solution to warm to about 10°C to about 25°C, preferably about 25°C and for about 1 to about 24 hours, preferably about 16 hours.

In step 2 of Scheme 1 a compound of the formula IV is prepared by treating a compound of formula III, with a compound of formula VI in an inert solvent, preferably an ethereal solvent such as diethylether, dioxane or tetrahydrofuran, most preferably THF, at about 20°C to about the reflux temperature of the solvent, preferably about 20°C to about 25°C for about 1 hour to about 100 hours preferably about 12 hours to about 16 hours, in the presence of triphenylphosphine and an ester or amide of diazodicarboxylic acid, preferably diisopropyl azodicarboxylate.

In step 3 of Scheme 1, a solution of the compound of formula IV is a) treated with acid in a solvent, according to procedures known in the art for removal of a Boc protective group, preferably HCl in ethyl acetate and b) the reaction product is then treated with formaldehyde and sodium triacetoxyborohydride or sodium cyanoborohydride, preferably sodium triacetoxyborohydride, in the presence of a suitable organic acid, preferably acetic acid, in an ethereal solvent such as diethylether, dioxane or tetrahydrofuran, or a chlorinated hydrocarbon solvent such as 1,2-dichloroethane, or a mixture of ethereal and chlorinated hydrocarbon solvents, preferably tetrahydrofuran, at about 20°C to about the reflux temperature of the solvent, preferably about 20°C to about 25°C, for about 1 to about 100 hours, preferably about 14 to about 16 hours to form a compound of formula I wherein Z is carbon. Although an N-methylated compound is exemplified in Scheme 1, those skilled in the art will recognize that after removal of the N-protective group, methods well known in the art may be used to produce other compounds corresponding to the definition of G as defined herein.

Scheme 2 refers to the preparation of a compound of the formula I wherein Z or W is nitrogen. Step 1 of Scheme 2 is identical to step 1 of Scheme 1 for the preparation of a compound of the formula III.

In step 2 of Scheme 2 a compound of the formula V is prepared by treating a compound of formula III, with a chloro, bromo or iodo pyridinyl compound of formula VII, preferably the bromo compound. The compound of formula III is treated with the compound of formula VII in an inert solvent, preferably an ethereal solvent such as diethylether, dioxane or tetrahydrofuran, most preferably THF, at about 20°C to about the reflux temperature of the

-12-

solvent, preferably about 20°C to about 25°C for about 1 hour to about 100 hours preferably about 12 hours to about 16 hours, in the presence of triphenylphosphine and an ester or amide of diazodicarboxylic acid, preferably diisopropyl azodicarboxylate.

In step 3 of Scheme 2 a compound of formula I, wherein Z is nitrogen is prepared by treating a compound of the formula V with an N-methyl piperazine in the presence of an iodide salt, preferably sodium iodide, in an ethereal solvent such as diethylether, dioxane or tetrahydrofuran, preferably dioxane, at a temperature of about 20°C to about the reflux temperature of the solvent, preferably at the reflux temperature of the solvent, for about 1 hour to about 200 hours, preferably about 115 hours to about 125 hours.

Scheme 3 refers to the preparation of a compound of the formula I wherein Z or W is nitrogen. Steps 1, 2 and 3 of Scheme 3 for the preparation of formula VIII are identical to steps 1, 2, and 3 of Scheme 1 for the preparation of a compound of the formula I. The N-vinyl protecting group in formula VIII substitutes for the N-aryl group of formula I to allow for substitution at the end of the synthesis.

In step 4 of Scheme 3, the N-vinyl protecting group is removed in a mixture of trifluoroacetic acid and water. Other acids such as hydrochloric acid and acetic acid may be used, again mixed with water. The reaction is typically run at 0°C, although temperatures from -50°C to reflux may be used, and the time is typically from 1 to 24 hours.

In step 5 of Scheme 3, the N-aryl group is added via a copper-mediated coupling reaction using a copper I salt such as copper (I) iodide or copper (I) bromide, and an alkali carbonate base such as potassium carbonate or sodium carbonate, an additive such as N,N'-dimethylethylenediamine, in a hydrocarbon solvent such as toluene. The temperature used is from room temperature to reflux, and the time is from 1 to 72 hours.

Compounds of formula I may be converted into pharmaceutically acceptable salts by methods well known to those skilled in the art.

Compounds of Formula I in which one or more atoms are radioactive may be prepared by methods known to a person of ordinary skill in the art. For example, compounds of Formula I wherein the radioactive atom is tritium may be prepared by reacting an aryl halide Ar-X, wherein the halogen is chlorine, bromine or iodine, with gaseous  $^3\text{H}_2$  and a noble metal catalyst, such as palladium suspended on carbon, in a suitable solvent such as a lower alcohol, preferably methanol or ethanol. Compounds of Formula I wherein the radioactive atom is  $^{18}\text{F}$  may be prepared by reacting an aryl trialkyl stannane  $\text{Ar-SnR}_3$ , wherein R is lower alkyl, preferably methyl or n-butyl, with  $^{18}\text{F}$ -enriched fluorine ( $\text{F}_2$ ),  $\text{OF}_2$  or  $\text{CF}_3\text{COOH}$  in a suitably inert solvent (*cf. M. Namavari, et al., J. Fluorine Chem.*, 74, 113 (1995)).

Compounds of Formula I wherein the radioactive atom is  $^{14}\text{C}$  may be prepared by reacting an aryl halide Ar-X, wherein X is preferably bromine or iodine, or an aryl trifluoromethane sulfonate ( $\text{Ar-OSO}_2\text{CF}_3$ ) with potassium [ $^{14}\text{C}$ ]cyanide or potassium [ $^{14}\text{C}$ ]-

cyanide and a noble metal catalyst, preferably tetra-kis(triphenylphosphine)palladium, in a reaction inert solvent such water or tetrahydrofuran, and preferably a mixture of water and tetrahydrofuran. (See Y. Andersson, B. Langstrom, *J. Chem. Soc. Perkin Trans. 1*, 1395 (1994).)

5       The therapeutic compounds used in the methods of this invention can be administered orally, buccally, trans-dermally (e.g., through the use of a patch), parenterally or topically. Oral administration is preferred. In general, these compounds are most desirably administered in dosages ranging from about 1 mg to about 1000 mg per day, although variations may occur depending on the weight and condition of the person being treated and  
10      the particular route of administration chosen. In some instances, dosage levels below the lower limit of the aforesaid range may be more than adequate, while in other cases still larger doses may be employed without causing any harmful side effect, provided that such larger doses are first divided into several small doses for administration throughout.

When used in the same oral, parenteral or buccal pharmaceutical composition as an  
15      SRI, the daily dose of the compound of formula I or pharmaceutically acceptable salt thereof will be within the same general range as specified above for the administration of such compound or salt as a single active agent. The daily dose of the SRI in such a composition will generally be within the range of about 1 mg to about 400 mg.

The therapeutic compounds used in the methods of this invention may be  
20      administered alone or in combination with pharmaceutically acceptable carriers or diluents by either of the two routes previously indicated, and such administration may be carried out in single or multiple doses. More particularly, the therapeutic compounds used in the methods of this invention can be administered in a wide variety of different dosage forms, i.e., they may be combined with various pharmaceutically acceptable inert carriers in the form of tablets,  
25      capsules, lozenges, troches, hard candies, powders, sprays, creams, salves, suppositories, jellies, gels, pastes, lotions, ointments, elixirs, syrups, and the like. Such carriers include solid diluents or fillers, sterile aqueous media and various non-toxic organic solvents, for example. Moreover, oral pharmaceutical compositions can be suitably sweetened and/or flavored.

For oral administration, tablets containing various excipients such as microcrystalline  
30      cellulose, sodium citrate, calcium carbonate, dicalcium phosphate and glycine may be employed along with various disintegrants such as starch (and preferably corn, potato or tapioca starch), alginic acid and certain complex silicates, together with granulation binders like polyvinylpyrrolidone, sucrose, gelatin and acacia. Additionally, lubricating agents such as magnesium stearate, sodium lauryl sulfate and talc are often very useful for tableting  
35      purposes. Solid compositions of a similar type may also be employed as fillers in gelatin capsules; preferred materials in this connection also include lactose or milk sugar as well as high molecular weight polyethylene glycols. When aqueous suspensions and/or elixirs are

desired for oral administration, the active ingredient may be combined with various sweetening or flavoring agents, coloring matter or dyes, and, if so desired, emulsifying and/or suspending agents as well, together with such diluents as water, ethanol, propylene glycol, glycerin and various like combinations thereof.

5 For parenteral administration, solutions of a therapeutic compound used in the methods of the present invention in either sesame or peanut oil or in aqueous propylene glycol may be employed. The aqueous solutions should be suitably buffered if necessary and the liquid diluent first rendered isotonic. These aqueous solutions are suitable for intravenous injection purposes. The oily solutions are suitable for intra-articular, intramuscular and  
10 subcutaneous injection purposes. The preparation of all these solutions under sterile conditions is readily accomplished by standard pharmaceutical techniques well known to those skilled in the art.

The activity of the compounds of the present invention with respect to 5HT<sub>1B</sub> (formerly 5HT<sub>1D</sub>) binding ability can be determined using standard radioligand binding assays as  
15 described in the literature. The compounds of the present invention show K<sub>i</sub> values in the 5HT<sub>1B</sub> binding assay of less than 100 nM. The 5-HT<sub>1A</sub> affinity can be measured using the procedure of Hoyer *et al.* (*Brain Res.*, 376, 85 (1986)). The 5-HT<sub>1D</sub> affinity can be measured using the procedure of Heuring and Peroutka (*J. Neurosci.*, 7, 894 (1987)).

The *in vitro* activity of the compounds of the present invention at the 5-HT<sub>1D</sub> binding  
20 site may be determined according to the following procedure. Bovine caudate tissue is homogenized and suspended in 20 volumes of a buffer containing 50 mM TRIS-HCl (tris[hydroxymethyl]aminomethane hydrochloride) at a pH of 7.7. The homogenate is then centrifuged at 45,000 G for 10 minutes. The supernatant is then discarded and the resulting pellet resuspended in approximately 20 volumes of 50 mM TRIS-HCl buffer at pH 7.7. This  
25 suspension is then pre-incubated for 15 minutes at 37°C, after which the suspension is centrifuged again at 45,000 G for 10 minutes and the supernatant discarded. The resulting pellet (approximately 1 gram) is resuspended in 150 ml of a buffer of 15 mM TRIS-HCl containing 0.01 percent ascorbic acid with a final pH of 7.7 and also containing 10  $\mu$ M pargyline and 4 mM calcium chloride (CaCl<sub>2</sub>). The suspension is kept on ice at least 30  
30 minutes prior to use.

The inhibitor, control or vehicle is then incubated according to the following procedure. To 50  $\mu$ l of a 20 percent dimethylsulfoxide (DMSO)/80 percent distilled water solution is added 200  $\mu$ l of tritiated 5-hydroxytryptamine (2 nM) in a buffer of 50 mM TRIS.hydrochloride containing 0.01 percent ascorbic acid at pH 7.7 and also containing 10  
35  $\mu$ M pargyline and 4  $\mu$ M calcium chloride, plus 100 nM of 8-hydroxy-DPAT (dipropylaminotetraline) and 100 nM of mesulergine. To this mixture is added 750  $\mu$ l of bovine caudate tissue, and the resulting suspension is vortexed to ensure a homogenous

suspension. The suspension is then incubated in a shaking water bath for 30 minutes at 25°C. After incubation is complete, the suspension is filtered using glass fiber filters (e.g., Whatman GF/B-filters.TM.). The pellet is then washed three times with 4 ml of a buffer of 50 mM TRIS.hydrochloride at pH 7.7. The pellet is then placed in a scintillation vial with 5 ml of scintillation fluid (aquasol 2<sup>TM</sup>) and allowed to sit overnight. The percent inhibition can be calculated for each dose of the compound. An IC<sub>50</sub> value can then be calculated from the percent inhibition values.

The activity of the compounds of the present invention for 5-HT<sub>1A</sub> binding ability can be determined according to the following procedure. Rat brain cortex tissue is homogenized and divided into samples of 1 gram lots and diluted with 10 volumes of 0.32 M sucrose solution. The suspension is then centrifuged at 900G for 10 minutes and the supernate separated and recentrifuged at 70,000 G for 15 minutes. The supernate is discarded and the pellet re-suspended in 10 volumes of 15 mM TRIS-HCl at pH 7.5. The suspension is allowed to incubate for 15 minutes at 37°C. After pre-incubation is complete, the suspension is centrifuged at 70,000 G for 15 minutes and the supernate discarded. The resulting tissue pellet is resuspended in a buffer of 50 mM TRIS.hydrochloride at pH 7.7 containing 4 mM of calcium chloride and 0.01 percent ascorbic acid. The tissue is stored at -70° C until ready for an experiment. The tissue can be thawed immediately prior to use, diluted with 10 µm pargyline and kept on ice.

The tissue is then incubated according to the following procedure. Fifty microliters of control, inhibitor, or vehicle (1 percent DMSO final concentration) is prepared at various dosages. To this solution is added 200 µl of tritiated DPAT at a concentration of 1.5 nM in a buffer of 50 mM TRIS-HCl at pH 7.7 containing 4 mM calcium chloride, 0.01 percent ascorbic acid and pargyline. To this solution is then added 750 µl of tissue and the resulting suspension is vortexed to ensure homogeneity. The suspension is then incubated in a shaking water bath for 30 minutes at 37°C. The solution is then filtered, washed twice with 4 ml of 10 mM TRIS-HCl at pH 7.5 containing 154 mM of sodium chloride. The percent inhibition is calculated for each dose of the compound, control or vehicle. IC<sub>50</sub> values are calculated from the percent inhibition values.

The agonist and antagonist activities of the compounds of the invention at 5-HT<sub>1A</sub> and 5-HT<sub>1D</sub> receptors can be determined using a single saturating concentration according to the following procedure. Male Hartley guinea pigs are decapitated and 5-HT<sub>1A</sub> receptors are dissected out of the hippocampus, while 5-HT<sub>1D</sub> receptors are obtained by slicing at 350 mM on a Mclwain tissue chopper and dissecting out the substantia nigra from the appropriate slices. The individual tissues are homogenized in 5 mM HEPES buffer containing 1 mM EGTA (pH 7.5) using a hand-held glass-Teflon<sup>®</sup> homogenizer and centrifuged at 35,000xg for 10 minutes at 4°C. The pellets are resuspended in 100 mM HEPES buffer containing 1 mM



EGTA (pH 7.5) to a final protein concentration of 20 mg (hippocampus) or 5 mg (substantia nigra) of protein per tube. The following agents are added so that the reaction mix in each tube contained 2.0 mM  $\text{MgCl}_2$ , 0.5 mM ATP, 1.0 mM cAMP, 0.5 mM IBMX, 10 mM phosphocreatine, 0.31 mg/mL creatine phosphokinase, 100  $\mu\text{M}$  GTP and 0.5-1 microcuries of  $[\text{P}^{32}]\text{-ATP}$  (30 Ci/mmol: NEG-003—New England Nuclear). Incubation is initiated by the addition of tissue to siliconized microfuge tubes (in triplicate) at 30° C. for 15 minutes. Each tube receives 20  $\mu\text{L}$  tissue, 10  $\mu\text{L}$  drug or buffer (at 10x final concentration), 10  $\mu\text{L}$  32 nM agonist or buffer (at 10x final concentration), 20  $\mu\text{L}$  forskolin (3  $\mu\text{M}$  final concentration) and 40  $\mu\text{L}$  of the preceding reaction mix. Incubation is terminated by the addition of 100  $\mu\text{L}$  2% SDS, 1.3 mM cAMP, 45 mM ATP solution containing 40,000 dpm  $[\text{H}^3]\text{-cAMP}$  (30 Ci/mmol: NET-275—New England Nuclear) to monitor the recovery of cAMP from the columns. The separation of  $[\text{P}^{32}]\text{-ATP}$  and  $[\text{P}^{32}]\text{-cAMP}$  is accomplished using the method of Salomon et al., Analytical Biochemistry, 1974, 58, 541-548. Radioactivity is quantified by liquid scintillation counting. Maximal inhibition is defined by 10  $\mu\text{M}$  (R)-8-OH-DPAT for 5-HT<sub>1A</sub> receptors, and 320 nM 5-HT for 5-HT<sub>1D</sub> receptors. Percent inhibitions by the test compounds are then calculated in relation to the inhibitory effect of (R)-8-OH-DPAT for 5-HT<sub>1A</sub> receptors or 5-HT for 5-HT<sub>1D</sub> receptors. The reversal of agonist induced inhibition of forskolin-stimulated adenylate cyclase activity is calculated in relation to the 32 nM agonist effect.

The compounds of the invention can be tested for in vivo activity for antagonism of 5-HT<sub>1D</sub> agonist-induced hyperthermia in guinea pigs according to the following procedure.

Male Hartley guinea pigs from Charles River, weighing 250-275 grams on arrival and 300-600 grams at testing, serve as subjects in the experiment. The guinea pigs are housed under standard laboratory conditions on a 7 a.m. to 7 p.m. lighting schedule for at least seven days prior to experimentation. Food and water are available ad libitum until the time of testing.

The compounds of the invention can be administered as solutions in a volume of 1 ml/kg. The vehicle used is varied depending on compound solubility. Test compounds are typically administered either sixty minutes orally (p.o.) or 0 minutes subcutaneously (s.c.) prior to a 5-HT<sub>1D</sub> agonist, such as [3-(1-methylpyrrolidin-2-ylmethyl)-1H-indol-5-yl]-(3-nitropyridin-3-yl)-amine, which can be prepared as described in PCT publication WO93/11106, published Jun. 10, 1993 which is administered at a dose of 5.6 mg/kg, s.c. Before a first temperature reading is taken, each guinea pig is placed in a clear plastic shoe box containing wood chips and a metal grid floor and allowed to acclimate to the surroundings for 30 minutes. Animals are then returned to the same shoe box after each temperature reading. Prior to each temperature measurement each animal is firmly held with one hand for a 30-second period. A digital thermometer with a small animal probe is used for temperature measurements. The probe is made of semi-flexible nylon with an epoxy tip. The temperature probe is inserted 6

cm. into the rectum and held there for 30 seconds or until a stable recording is obtained. Temperatures are then recorded.

In p.o. screening experiments, a "pre-drug" baseline temperature reading is made at -90 minutes, the test compound is given at -60 minutes and an additional -30 minute reading is taken. The 5-HT<sub>1D</sub> agonist is then administered at 0 minutes and temperatures are taken 30, 60, 120 and 240 minutes later. In subcutaneous screening experiments, a pre-drug baseline temperature reading is made at -30 minutes. The test compound and 5-HT<sub>1D</sub> agonists are given concurrently and temperatures are taken at 30, 60, 120 and 240 minutes later.

Data are analyzed with two-way analysis of variants with repeated measures in Newman-Keuls post hoc analysis.

The active compounds of the invention can be evaluated as anti-migraine agents by testing the extent to which they mimic sumatriptan in contracting the dog isolated saphenous vein strip (P.P.A. Humphrey *et al.*, *Br. J. Pharmacol.*, 94, 1128 (1988)). This effect can be blocked by methiothepin, a known serotonin antagonist. Sumatriptan is known to be useful in the treatment of migraine and produces a selective increase in carotid vascular resistance in the anesthetized dog. The pharmacological basis of sumatriptan efficacy has been discussed in W. Fenwick *et al.*, *Br. J. Pharmacol.*, 96, 83 (1989).

The serotonin 5-HT<sub>1</sub> agonist activity can be determined by the in vitro receptor binding assays, as described for the 5-HT<sub>1A</sub> receptor using rat cortex as the receptor source and [<sup>3</sup>H]-8-OH-DPAT as the radioligand (D. Hoyer *et al.* *Eur. J. Pharm.*, 118, 13 (1985)) and as described for the 5-HT<sub>1D</sub> receptor using bovine caudate as the receptor source and [<sup>3</sup>H]serotonin as the radioligand (R. E. Heuring and S. J. Peroutka, *J. Neuroscience*, 7, 894 (1987)).

The following Examples illustrate the preparation of the compounds of the invention.

#### EXAMPLE 1

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one hydrochloride, (I, X=CF<sub>3</sub>, n=1)

A. 3-Hydroxy-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one: (Referring to Scheme 1) To a 100 mL round-bottomed flask equipped with septum and N<sub>2</sub> inlet were added 600 mg (2.62 mmol) 1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one and 25 mL dry tetrahydrofuran. The solution was cooled to -78°C, and 5.24 mL (5.24 mmol) of a 1 M solution of lithium hexamethyldisilazide in tetrahydrofuran was added, and the reaction was stirred at -78°C for 45 minutes. Then a solution of 856 mg (3.27 mmol) of N-(benzenesulfonyl)phenyloxaziridine in 5 mL dry tetrahydrofuran was added, and the reaction allowed to warm to room temperature and stirred overnight. The reaction was quenched with aqueous ammonium chloride solution and diluted with ethyl acetate, and the layers were separated. The aqueous phase was extracted three times with ethyl acetate, and the

combined organic phase dried over magnesium sulfate and evaporated. The residue was chromatographed on silica gel with hexane/ethyl acetate to afford 241 mg (38%) of a white solid.

<sup>1</sup>H-NMR (CDCl<sub>3</sub>, δ): 2.11 (m, 1H), 2.62 (m, 1H), 3.7-3.9 (m, 2H), 4.94 (dd, J=2,10, 1H), 7.61 (d, J=8, 1H), 7.77 (d, J=8, 1H).

APCI MS: 246 (parent+1).

B. 3-[2-(4-t-Butoxycarbonyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one: To a 100 mL round-bottomed flask equipped with condenser and N<sub>2</sub> inlet were added 241 mg (0.983 mmol) 3-hydroxy-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one, 15 mL dry tetrahydrofuran, 645 mg (2.45 mmol) triphenylphosphine, and 328 mg (1.18 mmol) N-(2-hydroxyphenyl)-4-t-butoxycarbonyl-piperazine. A solution of 398 mg (1.97 mmol) diisopropyl azodicarboxylate in 10 mL dry tetrahydrofuran was added dropwise over 5 minutes, and the reaction stirred at room temperature overnight. The reaction was quenched with aqueous sodium bicarbonate solution, separated, and the aqueous layer extracted three times with ethyl acetate. The combined organic layers were dried over magnesium sulfate and evaporated. The residue was chromatographed on silica using hexane/ethyl acetate as eluant to afford 320 mg (64%) of an oil.

<sup>1</sup>H-NMR (CDCl<sub>3</sub>, δ): 1.44 (s, 9H), 1.59 (bs, 1H), 2.36 (m, 1H), 2.62 (m, 1H), 2.9-3.1 (m, 4H), 3.5 (m, 1H), 3.83 (m, 1H), 3.95 (m, 1H), 5.13 (t, J=8, 1H), 6.8-7.1 (m, 4H), 7.62 (d, J=9, 2H), 7.81 (d, J=9, 2H).

APCI MS: 506 (parent+1).

C. 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one hydrochloride: To a 50 mL round-bottomed flask equipped with N<sub>2</sub> inlet were added 320 mg (0.634 mmol) 3-[2-(4-t-butoxycarbonyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one and 15 mL dry ethyl acetate. The reaction was saturated with dry HCl and stirred at room temperature for 2 hours. The reaction was evaporated and azeotroped with ether to afford a solid residue that was used directly as follows: To the residue in a 50 mL round-bottomed flask equipped with N<sub>2</sub> inlet were added 10 mL dry tetrahydrofuran, 0.109 mL (1.45 mmol) of a 37% solution of formaldehyde in water, 0.041 mL (0.723 mmol) acetic acid, and 306 mg (1.45 mmol) sodium triacetoxymethylborohydride. The reaction was stirred at room temperature overnight, then diluted with ethyl acetate and saturated aqueous sodium bicarbonate solution. The layers were separated, and the aqueous layer was washed three times with ethyl acetate. The combined organic layers were washed with brine, dried over magnesium sulfate, and evaporated. The residue was dissolved in ethyl acetate and the product extracted into 1N aqueous HCl; then the aqueous layer, after washing 2 times with ethyl acetate, was basified with solid potassium carbonate and extracted 3 times with ethyl acetate. The organic layer was dried over magnesium sulfate

-19-

and evaporated. The resulting oil was dissolved in ethyl acetate and treated with 2 mL of a solution of ethyl acetate saturated with HCl, then evaporated to a solid, 37 mg (13%), mp 137-162°C.

<sup>1</sup>H-NMR (CDCl<sub>3</sub>, δ): 2.32 (m, 1H), 2.37 (s, 3H), 2.61 (m, 1H), 2.66 (m, 4H), 3.1-3.3 (m, 4H), 3.83 (m, 1H), 3.96 (m, 1H), 5.125 (t, J=8, 1H), 6.9-7.1 (m, 4H), 7.62 (d, J=8, 2H), 7.82 (d, J=8, 2H).

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.60, 44.86, 45.91, 50.29, 55.44, 77.04, 118.59, 119.15, 119.39, 123.19, 123.89, 126.33, 126.36, 142.14, 143.00, 150.37, 171.02 (signals for CF<sub>3</sub> group not visible in this scan).

APCI MS: 420 (parent+1).

Anal. Calc'd. for C<sub>22</sub>H<sub>24</sub>F<sub>3</sub>N<sub>3</sub>O<sub>2</sub>HCl·3H<sub>2</sub>O: C 51.82, H 6.13, N 8.24. Found: C 51.70, H 6.15, N 7.90.

#### EXAMPLE 2

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-bromo-phenyl)-pyrrolidin-2-one, (I, X=Br, n=1): Prepared as in Example 1, in 52% yield, as an oil.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.57, 44.94, 45.90, 50.30, 55.38, 62.30, 77.04, 118.08, 118.40, 119.04, 121.33, 123.10, 123.71, 132.12, 138.32, 142.99, 150.43, 170.63.

APCI MS: 430/432 (parent+1, Br<sup>79/81</sup>).

#### EXAMPLE 3

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-(2-oxo-pyrrolidin-1-yl)-phenyl)-pyrrolidin-2-one, (I, X=2-oxo-pyrrolidin-1-yl, n=1): Prepared as in Example 1, in 60% yield, as a solid, mp 164-180°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 18.12, 26.66, 32.87, 45.12, 46.16, 48.93, 50.53, 55.57, 77.14, 118.40, 118.91, 120.32, 120.46, 122.99, 123.58, 135.60, 136.52, 143.10, 150.54, 170.44, 174.41..

APCI MS: 435 (parent+1).

#### EXAMPLE 4

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-bromo-phenyl]-piperidin-2-one, (I, X=Br, n=2): Prepared as in Example 1, in 25% yield, as an oil.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 19.90, 27.74, 46.22, 50.58, 50.91, 55.73, 75.20, 118.93, 119.27, 120.38, 123.02, 123.42, 127.70, 132.41, 141.85, 143.26, 150.59, 168.31.

APCI MS: 444/446 (parent+1, Br<sup>79/81</sup>).

#### EXAMPLE 5

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-pyrrolidin-1-yl)-phenyl]-piperidin-2-one, (I, X=2-oxo-pyrrolidin-1-yl, n=2): Prepared as in Example 1, in 52% yield, as a solid, mp 68-75°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 18.15, 19.91, 27.77, 32.83, 46.21, 48.99, 50.58, 51.10, 55.72, 75.27, 118.84, 119.17, 120.86, 122.96, 123.27, 126.47, 138.02, 139.03, 143.25, 150.68, 168.31, 174.46.

APCI MS: 449 (parent+1).

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#### EXAMPLE 6

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-oxazolidin-3-yl)-phenyl]-piperidin-2-one, (I, X=2-oxo-oxazolidin-3-yl, n=2): Prepared as in Example 1, in 52% yield, as a solid, mp 71-88°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 19.92, 27.76, 45.42, 46.12, 50.47, 51.13, 55.67, 61.51, 75.24, 118.93, 119.17, 123.04, 123.33, 126.75, 136.90, 138.75, 143.18, 150.65, 155.44, 168.37.

APCI MS: 451 (parent+1).

#### EXAMPLE 7

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-piperidin-2-one, (I, X=CF<sub>3</sub>, n=2): Prepared as in Example 1, in 30% yield, as a solid, mp 81-110°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 19.93, 27.68, 46.18, 50.18, 50.58, 55.70, 75.22, 119.01, 119.31, 123.05, 123.52, 126.04, 126.37, 143.29, 145.86, 150.52, 168.49, 173.32 (CF<sub>3</sub> carbon missing in this scan).

APCI MS: 434 (parent+1).

#### EXAMPLE 8

1-(4-Bromo-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one, (I, X=Br, n=1, Z=N):

A. 1-(4-bromophenyl)-3-hydroxy-2-pyrrolidinone: Prepared as in Example 1A, using 1-(4-bromophenyl)-2-pyrrolidinone, to afford the product in 46% yield after conversion of some of the corresponding trimethylsilyloxy analogue to the desired hydroxy compound.

APCI MS: 256/258 (parent+1, Br<sup>79/81</sup>).

B. 1-(4-Bromo-phenyl)-3-(2-bromo-pyridin-3-yloxy)-pyrrolidin-2-one: Prepared as in Example 1B in 40% yield after chromatography with ethyl acetate/hexane on silica gel.

APCI MS: 412/414 (parent+1, Br<sup>79/81</sup>).

C. 1-(4-Bromo-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: To a 100 mL round-bottomed flask equipped with condenser and N<sub>2</sub> inlet were added 1.15 g (2.79 mmol) of 1-(4-bromo-phenyl)-3-(2-bromo-pyridin-3-yloxy)-pyrrolidin-2-one, 1.6 mL (13.96 mmol) 1-methylpiperazine, 0.418 g (2.79 mmol) sodium iodide, and 20 mL dioxane. The reaction was refluxed 5 days, cooled, taken up in ethyl acetate, washed with water, dried over sodium sulfate, and evaporated. The residue was chromatographed on silica gel using methanol/ethyl acetate to afford the desired product in 35% yield as a foam, which was converted to the hydrochloride salt, mp 72-82°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.43, 44.87, 46.34, 48.28, 55.41, 76.86, 116.97, 118.31, 121.32, 124.85, 132.19, 138.12, 141.58, 144.88, 153.17, 170.24.

APCI MS: 431/433 (parent+1, Br<sup>79/81</sup>).

#### EXAMPLE 9

5     1-(4-tert-Butyl-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one:  
Prepared as in Example 8, in 18% yield, as a solid, mp 131-164°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.59, 31.51, 34.63, 45.09, 46.42, 48.39, 55.50, 77.03, 116.89, 119.79, 124.58, 126.04, 136.43, 141.32, 145.02, 148.45, 153.23, 169.97.

APCI MS: 409 (parent+1).

10     Anal. Calc'd. for C<sub>24</sub>H<sub>32</sub>N<sub>4</sub>O<sub>2</sub>·2HCl·1/2H<sub>2</sub>O: C 58.77, H 7.19, N 11.42. Found: C 58.96, H 7.14, N 11.33.

#### EXAMPLE 10

1-[4-(2-tert-Butyl-oxazol-4-yl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: Prepared as in Example 8, in 53% yield, as a solid, mp 81-175°C.

15     <sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.46, 28.78, 34.00, 44.91, 46.42, 48.39, 55.48, 76.98, 116.91, 119.87, 124.58, 126.24, 128.59, 132.97, 138.48, 139.68, 141.35, 144.99, 153.18, 170.18, 171.80.

APCI MS: 476 (parent+1).

20     Anal. Calc'd. for C<sub>27</sub>H<sub>33</sub>N<sub>5</sub>O<sub>3</sub>·2HCl·1H<sub>2</sub>O: C 57.24, H 6.58, N 12.36. Found: C 57.63, H 6.47, N 12.48.

#### EXAMPLE 11

1-[4-(3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-2-oxo-pyrrolidin-1-yl)-phenyl]-piperidin-2-one: Prepared as in Example 8, in 33% yield, as a solid, mp 111-149°C.

25     <sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 21.64, 23.71, 26.52, 33.06, 45.10, 46.40, 48.36, 51.83, 55.47, 116.93, 120.76, 124.69, 126.97, 137.32, 140.42, 141.44, 144.94, 153.21, 170.17, 170.38.

APCI MS: 450 (parent+1).

#### EXAMPLE 12

1-(4-(3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-2-oxo-pyrrolidin-1-yl)-phenyl)-pyrrolidinone: Prepared as in Example 8, in 52% yield, as a solid, mp 151-212°C.

30     <sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 18.10, 26.48, 32.87, 45.03, 46.44, 48.39, 48.89, 55.50, 76.94, 116.90, 120.29, 120.42, 124.58, 129.19, 135.34, 136.67, 141.36, 144.99, 153.20, 170.04, 174.41.

APCI MS: 436 (parent+1).

35     Anal. Calc'd. for C<sub>24</sub>H<sub>29</sub>N<sub>5</sub>O<sub>3</sub>·2HCl: C 56.69, H 6.15, N 13.77. Found: C 56.70, H 6.22, N 13.23.

-22-

**EXAMPLE 13**1-[4-(3-pyridyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one:

Prepared as in Example 8, in 44% yield, as a solid, mp 142-235°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.52, 44.95, 46.46, 48.42, 55.52, 76.94, 116.91, 120.36,  
123.81, 124.80, 127.82, 134.29, 134.66, 135.90, 139.05, 141.53, 144.92, 148.30, 148.73,  
153.26, 170.34.

APCI MS: 430 (parent+1).

**EXAMPLE 14**1-[4-(4-pyridyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one:

Prepared as in Example 8, in 47% yield, as a solid, mp 145-230°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.47, 44.89, 46.45, 48.42, 55.51, 76.89, 116.91, 120.19,  
121.45, 124.81, 127.72, 134.70, 139.87, 141.54, 144.88, 147.42, 150.54, 153.26, 170.42.

APCI MS: 430 (parent+1).

**EXAMPLE 15**

15 1-[4-(isopropoxy)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: Prepared as in Example 8, in 61% yield, as a solid, mp 93-120°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 22.17, 26.54, 45.37, 46.44, 48.39, 55.50, 70.38, 76.95, 116.38,  
116.82, 121.71, 124.41, 132.02, 141.20, 145.02, 153.17, 155.45, 169.71.

APCI MS: 411 (parent+1).

20 Anal. Calc'd. for C<sub>23</sub>H<sub>30</sub>N<sub>4</sub>O<sub>3</sub>·2HCl·1/2H<sub>2</sub>O: C 56.10, H 6.75, N 11.38. Found: C 56.50, H 7.07, N 11.23.

**EXAMPLE 16**

1-[4-(Trifluoromethoxy)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: Prepared as in Example 8, in 61% yield, as a solid, mp 113-140°C.

25 <sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.41, 26.51, 44.98, 46.41, 48.41, 55.49, 76.77, 116.88,  
119.93, 121.00, 121.81, 124.57, 124.78, 125.38, 129.16, 137.67, 141.32, 141.53, 144.84,  
146.00, 153.25, 170.28.

APCI MS: 437 (parent+1).

30 Anal. Calc'd. for C<sub>21</sub>H<sub>23</sub>F<sub>3</sub>N<sub>4</sub>O<sub>3</sub>·2HCl: C 49.52, H 4.95, N 11.00. Found: C 49.92, H 5.30, N 11.01.

**EXAMPLE 17**

3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-1-[4-(tetrahydro-pyran-4-yl)-phenyl]-pyrrolidin-2-one: Prepared as in Example 8, except that the last steps followed Scheme 3.

35 A. 3-[2-Bromo-pyridinyl-3-oxy]-1-vinyl-pyrrolidin-2-one: Prepared as in Example 1B using 3-hydroxy-1-vinyl-pyrrolidin-2-one (prepared as in Example 1A) and 2-bromo-3-hydroxypyridine in 100% yield after column chromatography on silica gel.

-23-

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.08, 41.71, 77.68, 96.97, 123.67, 124.30, 128.67, 129.13, 132.07, 133.10, 143.15

APCI MS: 283/285 (parent+1).

B. 1-Vinyl-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one:

5 Prepared as in Example 8B, in 25% yield.

APCI MS: 303 (parent+1).

C. 3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-1-[4-(tetrahydro-pyran-4-yl)-phenyl]-pyrrolidin-2-one: The vinyl group in 1-vinyl-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one was hydrolyzed using 30 mL of 5:1 trifluoroacetic acid:water at 0°C for 4 hr, concentrated, diluted with aqueous sodium hydroxide solution and extracted into ethyl acetate. The organic layer was dried over magnesium sulfate and evaporated. The aqueous layer was also re-extracted to give additional material, and the residue was chromatographed on silica gel to afford 1.2 g (62%) of an oil (APCI MS: 277, parent +1). This oil was treated with 1.2 equivalents of 4-bromophenyl-4-tetrahydropyran, 1.1 equivalents of copper iodide, 1.1 equivalents of N,N'-dimethylethylenediamine, and 1.5 equivalents of potassium carbonate in toluene at reflux to afford, after chromatography on silica gel, a 64% yield of product as a solid, mp 219-248°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.56, 34.08, 41.16, 45.09, 46.44, 48.39, 55.50, 68.48, 76.98, 116.88, 120.25, 124.58, 127.44, 137.24, 141.34, 143.11, 144.98, 153.21, 170.03.

20 APCI MS: 437 (parent+1).

Anal. Calc'd. for C<sub>25</sub>H<sub>32</sub>N<sub>4</sub>O<sub>3</sub>·2HCl·1/4H<sub>2</sub>O: C 58.42, H 6.77, N 10.90. Found: C 58.40, H 6.72, N 10.87.

#### EXAMPLE 18

1-[4-(2-Oxazoly)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: Prepared as in Example 8, in 74% yield, as a solid, mp 98-169°C.

<sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.38, 44.77, 46.43, 48.40, 55.48, 76.83, 116.89, 119.57, 124.14, 124.73, 127.26, 128.63, 138.80, 140.73, 141.49, 144.85, 153.21, 161.55, 170.47.

APCI MS: 420 (parent+1).

30 Anal. Calc'd. for C<sub>28</sub>H<sub>28</sub>N<sub>5</sub>O<sub>3</sub>·2HCl·1H<sub>2</sub>O: C 54.12, H 5.73, N 13.72. Found: C 54.30, H 5.40, N 13.42.

#### EXAMPLE 19

1-[4-(1-Pyazoly)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: Prepared as in Example 8, in 84% yield, as a solid, mp 98-176°C.

35 <sup>13</sup>C-NMR (CDCl<sub>3</sub>, δ): 26.41, 44.94, 46.44, 48.40, 55.49, 76.84, 107.97, 116.88, 119.64, 120.59, 124.59, 126.88, 137.15, 137.32, 141.32, 141.40, 144.92, 153.18, 170.22.

APCI MS: 419 (parent+1).



-24-

Anal. Calc'd. for  $C_{23}H_{26}N_6O_2 \cdot 3/2HCl \cdot 1/2H_2O$ : C 57.29 H 5.96 N 17.43. Found: C 57.11, H 6.02, N 17.25.

**EXAMPLE 20**

- 5 1-[4-(4-(2-Methyl)oxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: Prepared as in Example 8, in 77% yield, as a solid, mp 108-171°C.
- $^{13}C$ -NMR ( $CDCl_3$ ,  $\delta$ ): 14.16, 26.42, 44.69, 44.87, 46.40, 48.36, 55.46, 76.91, 116.88, 118.90, 119.90, 124.52, 126.06, 128.14, 129.61, 133.35, 138.59, 140.11, 141.32, 144.94, 153.14, 162.06, 170.18.
- APCI MS: 434 (parent+1).
- 10 Anal. Calc'd. for  $C_{24}H_{27}N_6O_3 \cdot 2HCl$ : C 56.92, H 5.77, N 13.83. Found: C 57.35, H 5.76, N 13.67.

**EXAMPLE 21**

- 1-[4-(3-Isoxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: Prepared as in Example 8, in 59% yield, as a solid, mp 220°C.
- 15  $^{13}C$ -NMR ( $CDCl_3$ ,  $\delta$ ): 26.41, 44.80, 46.42, 48.39, 55.48, 76.87, 102.57, 116.92, 119.85, 124.70, 125.45, 127.74, 140.53, 141.48, 144.90, 153.20, 159.24, 160.96, 170.46.
- APCI MS: 420 (parent+1).
- Anal. Calc'd. for  $C_{23}H_{25}N_6O_3 \cdot 2HCl \cdot 1/2H_2O$ : C 55.09, H 5.63, N 13.97. Found: C 55.42, H 5.50, N 13.70.

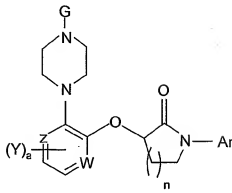
**EXAMPLE 22**

- 1-[4-(2-(5-Methyl)oxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one: Prepared as in Example 8, in 71% yield, as a solid, mp 98-176°C.
- 20  $^{13}C$ -NMR ( $CDCl_3$ ,  $\delta$ ): 12.03, 26.46, 44.90, 46.43, 48.40, 55.49, 76.94, 116.88, 119.90, 124.57, 127.26, 129.09, 133.63, 138.11, 141.35, 144.28, 144.95, 149.15, 153.20, 170.20.
- APCI MS: 434 (parent+1).
- Anal. Calc'd. for  $C_{24}H_{27}N_6O_3 \cdot 3/2HCl \cdot 1/2H_2O$ : C 57.98, H 5.98, N 14.09. Found: C 58.12, H 5.83, N 13.96.

-25-

CLAIMS

1. A compound of the formula I



- wherein Ar is selected from phenyl, naphthyl and heteroaryl, wherein said heteroaryl is selected from five to seven membered aromatic rings or eight to ten membered fused aromatic ring systems containing from one to four heteroatoms selected from oxygen, nitrogen and sulfur, and

- wherein Ar may be optionally substituted with one or more substituents, preferably from zero to two substituents, independently selected from halogen, trifluoromethyl, hydroxy, nitro, cyano,  $R_1$ ,  $OR_2$ ,  $-OC(=O)R_3$ ,  $-COOR_4$ ,  $NHR_5$ ,  $NR_5R_6$ ,  $-NHC(=O)R_6$ ,  $N(R_6)(C=O)R_6$ ,  $-C(=O)NHR_6$ , phenyl, naphthyl, heteroaryl, or a five to seven membered heteroalkyl ring, and

wherein said heteroaryl substituent is selected from five to seven membered aromatic rings containing from one to four heteroatoms selected from oxygen, nitrogen and sulfur, and

- wherein said five to seven membered heteroalkyl ring substituent has from zero to four heteroatoms selected from nitrogen, sulfur and oxygen, with the proviso that said ring cannot contain two adjacent oxygen atoms or two adjacent sulfur atoms, and

- wherein said phenyl, naphthyl, heteroaryl and heteroalkyl ring substituents may be optionally substituted with one or more substituents, independently selected from halogen, trifluoromethyl, hydroxy, nitro, cyano,  $R_1$ ,  $OR_2$ ,  $-OC(=O)R_3$ ,  $-COOR_4$ ,  $NHR_5$ ,  $NR_5R_6$ ,  $-NHC(=O)R_6$ ,  $N(R_6)(C=O)R_6$ ,  $-C(=O)NHR_6$  and wherein said heteroalkyl ring may also be substituted with oxo;

- Y is hydrogen, halogen, hydroxy, nitro, cyano or  $R_7$ , where  $R_1$ - $R_7$  are independently  $C_1$ - $C_8$  alkyl,  $C_2$ - $C_8$  alkenyl,  $C_1$ - $C_8$  alkoxy, or  $C_1$ - $C_8$  alkenoxy, said alkyl, alkenyl, alkoxy or alkenoxy being optionally substituted with one or more halogen atoms or nitro, cyano or hydroxyl groups, said alkyl or alkenyl groups being straight-chain, branched or cyclic, or, in the case of  $NR_5R_6$ ,  $R_5$  and  $R_6$  together with the nitrogen to which they are attached may be linked together to form a five or six membered ring;

-26-

G is (C<sub>1</sub>-C<sub>6</sub>)alkyl or benzyl, wherein said alkyl is straight-chained, branched or cyclic, and said (C<sub>1</sub>-C<sub>6</sub>) alkyl is optionally substituted with OH, or OR', wherein R' is straight-chained, branched or cyclic (C<sub>1</sub>-C<sub>6</sub>)alkyl;

a is 1 to 4;

5 Z and W are independently carbon or nitrogen;

n is 1, 2 or 3; and

the pharmaceutically acceptable salts thereof.

2. A compound according to claim 1 wherein Ar is a heteroaryl selected from furyl, thienyl, pyridyl, pyrimidyl, thiazolyl, pyrazolyl, isothiazolyl, oxazolyl, isooxazolyl, pyrrolyl, triazolyl, tetrazolyl and imidazolyl.

3. A compound according to claim 1 wherein Ar is phenyl having a para substituent selected from halogen, trifluoromethyl, phenyl or a five or six membered heteroaryl or a five or six membered heteroalkyl ring.

4. A compound according to claim 1 wherein Ar is phenyl having a para substituent selected from bromine, trifluoromethyl, 2-oxo-oxazolidin-3-yl or 2-oxo-pyrrolidin-1-yl.

5. A compound according to claim 1 selected from:

- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-oxazolidin-3-yl)-phenyl]-piperidin-2-one;
- 20 1-(4-Bromo-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one;
- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-bromo-phenyl)-pyrrolidin-2-one;
- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-(2-oxo-pyrrolidin-1-yl)-phenyl)-pyrrolidin-2-one;
- 25 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-bromo-phenyl]-piperidin-2-one;
- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-pyrrolidin-1-yl)-phenyl]-piperidin-2-one;
- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-oxazolidin-3-yl)-phenyl]-piperidin-2-one;
- 30 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-piperidin-2-one;
- 1-(4-Trifluoromethyl-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-(4-tert-Butyl-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-[4-(2-tert-Butyl-oxazol-4-yl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 35 1-(4-{3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-2-oxo-pyrrolidin-1-yl}-phenyl)-piperidin-2-one;

1-(4-{3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-2-oxo-pyrrolidin-1-yl}-phenyl)-pyrrolidinone;

1-[4-(3-pyridyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;

1-[4-(4-pyridyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;

5 1-[4-(Isopropoxy)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;

1-[4-(Trifluoromethoxy)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;

3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-1-[4-(tetrahydro-pyran-4-yl)-phenyl]-pyrrolidin-2-one;

10 1-[4-(2-Oxazoly)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;

1-[4-(1-Pyrazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;

15 1-[4-(4-(2-Methyl)oxazoly)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;

1-[4-(3-Isoxazoly)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one; and,

1-[4-(2-(5-Methyl)oxazoly)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one.

6. A pharmaceutical composition comprising a pharmaceutically effective amount of the compound of claim 1 and a pharmaceutically acceptable carrier.

7. A method of treating a disorder or condition in a mammal selected from the group consisting of anxiety, depression, dysthymia, major depressive disorder, migraine, post-traumatic stress disorder, avoidant personality disorder, borderline personality disorder and phobias, comprising administering to a mammal in need of such treatment an effective amount of the compound of claim 1 or a pharmaceutically acceptable salt thereof.

8. The method according to claim 7, wherein said compound is selected from:

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-oxazolidin-3-yl)-phenyl]-piperidin-2-one;

1-(4-Bromo-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-pyrrolidin-2-one;

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-bromo-phenyl)-pyrrolidin-2-one;

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-pyrrolidin-1-yl)-phenyl]-pyrrolidin-

35 2-one;

3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-bromo-phenyl)-piperidin-2-one;

-28-

- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-pyrrolidin-1-yl)-phenyl]-piperidin-2-one;
- 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-[4-(2-oxo-oxazolidin-3-yl)-phenyl]-piperidin-2-one;
- 5 3-[2-(4-Methyl-piperazin-1-yl)-phenoxy]-1-(4-trifluoromethyl-phenyl)-piperidin-2-one;
- 1-[4-(Trifluoromethyl-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-(4-tert-Butyl-phenyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-[4-(2-tert-Butyl-oxazol-4-yl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 10 1-(4-[3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-2-oxo-pyrrolidin-1-yl]-phenyl)-piperidin-2-one;
- 1-(4-[3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-2-oxo-pyrrolidin-1-yl]-phenyl)-pyrrolidinone;
- 15 1-[4-(3-pyridyl)-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-[4-(4-pyridyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-[4-(Isopropoxy)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-[4-(Trifluoromethoxy)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 20 3-[2-(4-Methyl-piperazin-1-yl)-pyridin-3-yloxy]-1-[4-(tetrahydro-pyran-4-yl)-phenyl]-pyrrolidin-2-one;
- 1-[4-(2-Oxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 25 1-[4-(1-Pyrazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-[4-(4-(2-Methyl)oxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one;
- 1-[4-(3-Isoxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one; and,
- 30 1-[4-(2-(5-Methyl)oxazolyl)-phenyl]-3-[2-(4-methyl-piperazin-1-yl)-pyridin-3-yloxy]-pyrrolidin-2-one.

9. The method according to claim 7, further comprising co-administering a serotonin reuptake inhibitor.

# INTERNATIONAL SEARCH REPORT

International Application No.  
PC 1 / IB2004/001942

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07D207/12 C07D211/40 C07D413/10 C07D401/12 C07D413/14  
C07D401/14 C07D405/14 A61K31/495 A61P25/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07D A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, CHEM ABS Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01/23374 A (NYMAN PAUL ADRIAN ; MARSHALL HOWARD (GB); THOMPSON MERVYN (GB); SMITHK) 5 April 2001 (2001-04-05) claims 1,15	1-9
A	WO 99/29666 A (GASTER LARAMIE MARY ; WYMAN PAUL ADRIAN (GB); SMITHKLINE BEECHAM PLC) 17 June 1999 (1999-06-17) page 1, line 14 - page 3, line 11	1-9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents:

\*A\* document defining the general state of the art which is not considered to be of particular relevance

\*E\* earlier document published on or after the international filing date

\*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

\*O\* document referring to an oral disclosure, use, exhibition or other means

\*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*Z\* document member of the same patent family

Date of the actual completion of the international search

22 September 2004

Date of mailing of the international search report

11/10/2004

Name and mailing address of the ISA  
European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel: (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Bakboord, J

# INTERNATIONAL SEARCH REPORT

national application No.  
PCT/IB2004/001942

## Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:  
  
Although claims 7-9 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compounds.
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.  
PCT/IB2004/001942

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0123374	A	05-04-2001	AT 259363 T 15-02-2004
			AU 765020 B2 04-09-2003
			AU 7783600 A 30-04-2001
			BR 0014279 A 21-05-2002
			CA 2385737 A1 05-04-2001
			CN 1399635 T 26-02-2003
			CZ 20021038 A3 14-08-2002
			DE 60008262 D1 18-03-2004
			DK 1216239 T3 14-06-2004
			WO 0123374 A1 05-04-2001
			EP 1216239 A1 26-06-2002
			ES 2211624 T3 16-07-2004
			HU 0202787 A2 28-12-2002
			JP 2003510317 T 18-03-2003
			NO 20021459 A 22-03-2002
			NZ 517865 A 28-11-2003
			SI 1216239 T1 31-08-2004
			TR 200200795 T2 22-07-2002
			US 6747030 B1 08-06-2004
			US 2004176388 A1 09-09-2004
			ZA 200202319 A 21-11-2002
WO 9929666	A	17-06-1999	WO 9929666 A1 17-06-1999